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PixMin Warm-Body Detection from Elevated Imagery: a case study

Warm Body Detection Potential

We, the Brainlike Team, have designed PixMin™ solutions for mobile, automatic detection of people, animals, and thermal anomalies over large regions of interest. PixMin automatically detects, pinpoints, and produces high resolution sub-images of warm bodies within massive imagery. By automatically identifying sub-images containing detected events, PixMin eliminates manual monitoring and minimizes image transmission. When deployed on towers, PixMin can cover large regions of interest persistently. When deployed on drones tethered to remote monitoring vehicles (RMVs), PixMin will be quickly deployable to remote regions. Applications include, but are not limited to, protecting people from entering dangerous areas, detecting lost people or animals, monitoring human or animal activity, maintaining security over large regions, and detecting non-biological thermal events of interest.

The right figure shows paired, thermal and visual frames from drone-based footage, which we obtained from a YouTube clip. The drone operator first spotted the thermal signature from footage like the red box on the top left frame. As shown in the red box in the frame below it, the source of the thermal image was not visually clear. After seeing the thermal signature, the operator zoomed in for closer looks, as shown by the three right-most image columns. The operator could then see that the thermal signature came from a bull elk, as shown in the frame below.

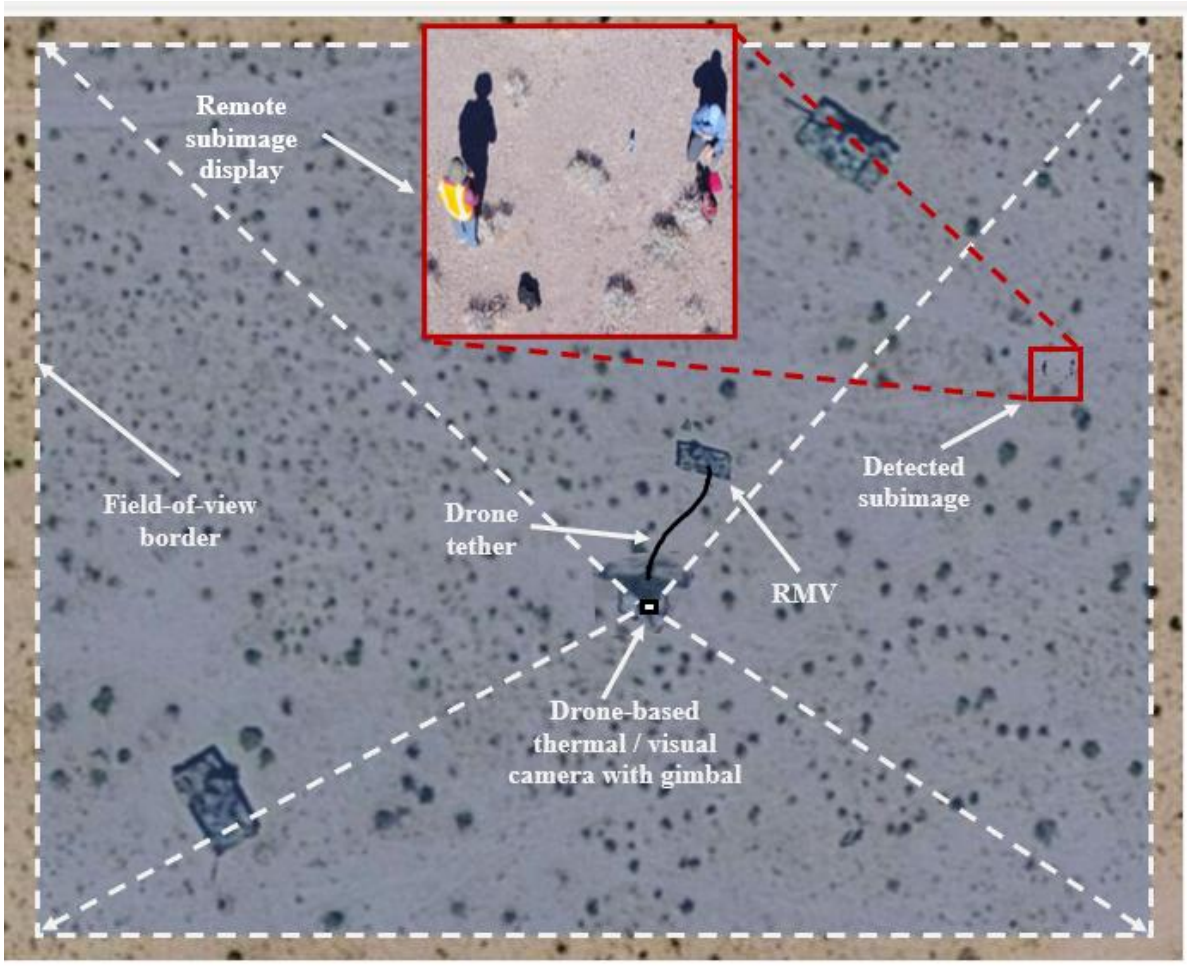
To detect and identify the animal, the drone operator had to notice the heat signature during continuous manual monitoring and then manually descend the drone for a closer look. By contrast, PixMin can find warm body signatures and zoom in automatically, freeing operators from continuous manual monitoring and control.

Our PixMin designs use commercially available, inexpensive components including drones, tethers, processors, cameras, gimbals, and automatic detection systems. Today's

drones routinely include tethers that connect them to ground power supplies. Tethered drones operate persistently from 100 m. or higher altitudes. Drone tethers also carry network cables, enabling full resolution image transmission to ground-based processors.

Today's drones routinely carry cameras that shoot dual, visual, and thermal imagery. Workswell, LLC makes our Wiris Pro camera of choice. Wiris Pro cameras produces high resolution dual imagery pairs that can be captured at about the same time with close pixel alignment, enabling effective automatic detection. Most notably, Wiris Pro cameras include industry leading and easily implemented control configurability, enabling remote processors to control frame rates as well as optical frame zoom control, all in real time. Wiris Pro cameras are routinely mounted on inexpensive gimbals, which may also be automatically controlled by remote processors. Our gimbal of choice enables automatic tilt and pan functions, with pan rates up to 180 degrees per second.

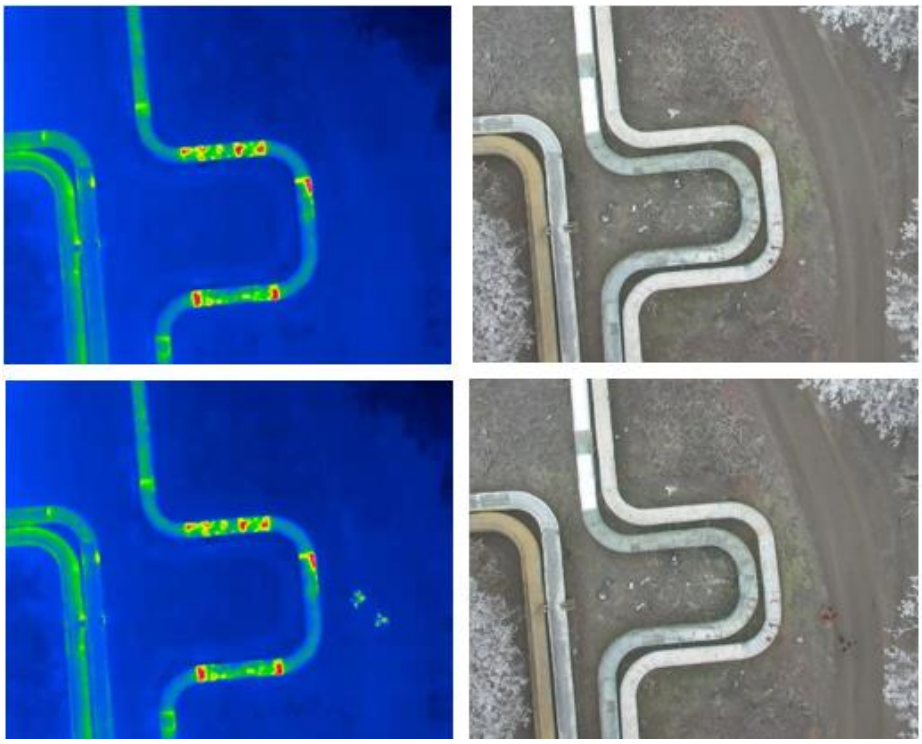
The figure below shows how PixMin can continuously monitor a region to notify operators when people may be moving toward harm's way. The figure represents the kind of monitoring coverage and event resolution that dual camera can produce. The coverage shown is about 120m by 90m when captured at an elevation of 100m. Later in this report, we will show how the same camera at the same elevation can cover more ground.



Case Study Results

The input imagery for this case study came from a Wiris Pro Camera. The manufacturer, Workswell, LLC, kindly provided the case study imagery along with operational camera insights. Workswell supplied video containing thermal and visual frames. Thermal and visual frames had different sizes. Visual image resolution was 1920×1080 and thermal resolution was 640×512. As a result, thermal and visual ground pixel coverage (GSD) differed. Pixel ground coverage also differed within pairs shot at the same time. Some ground covered by a typical visual image was not covered by its thermal counterpart and *vice versa*. Pixels were also misaligned from one pair to another, due to routine drone movement over time.

Input frames were extracted and converted to counterparts with the same resolution, ground coverage and GSD. Conversion steps were chosen that could be readily completed automatically on an edge-based processor within a few milliseconds per frame. Conversion produced 870×696 paired images that were captured at the same time. The figure on the right shows two converted image pairs from two different time slices. The pair on the top row resembles all image pairs that contained no people. The pair on the bottom row resembles all image pairs that contained two people as shown.

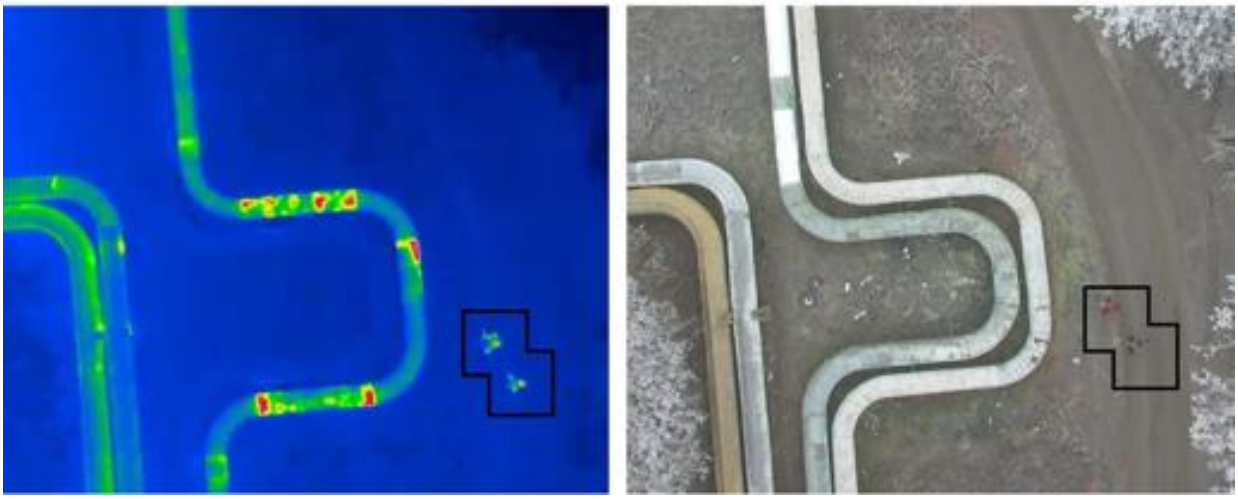


We selected 77 frame pairs for case study analysis. Among them, 55 contained people and 22 did not. We processed the 77 thermal images using PixMin, our automatic detection software of choice. We used PixMin because its following capabilities:

- High speed image processing. In this case, PixMin processed all 77 thermal images in less than a second.
- Automatic and precise change detection. In this case, we configured PixMin to detect events precisely as changes between each frame and a preceding counterpart.
- Automatic pixel alignment. In this case, we configured PixMin to contrast pixel-aligned images at one time point with pixels at a previous time point, enabling precise event change detection.

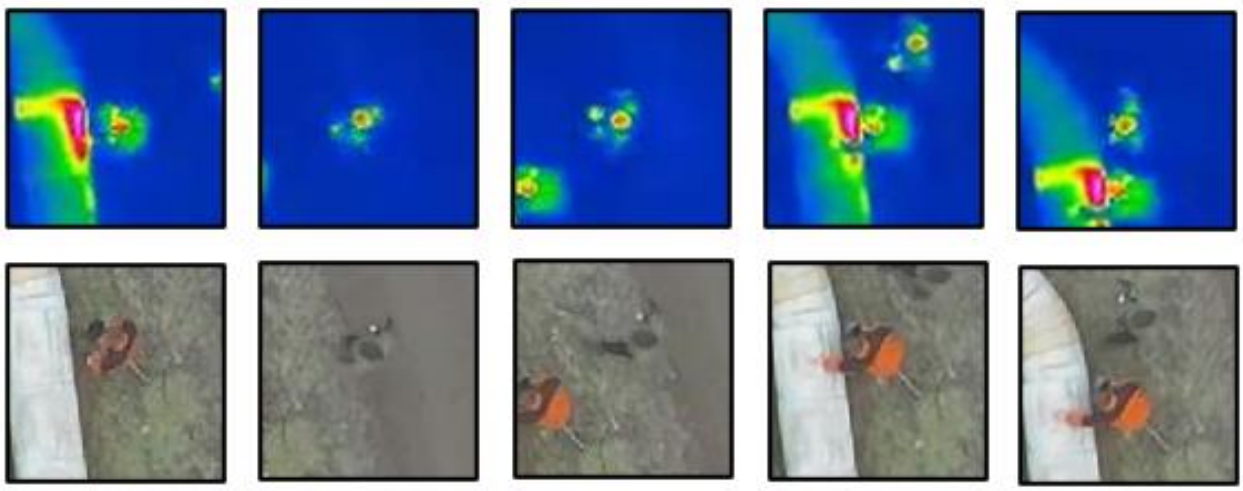
- Substantial operator effort reduction. PixMin will rarely alert operators because unusual events rarely occur. When events do occur, PixMin produces "alert maps" showing where events have been detected within frames, along with alerted sub-images called "chips," that show the events in full resolution detail.
- Substantial data reduction. PixMin alert maps may be compressed by 90:1 or higher using standard compression software. Full resolution PixMin chips typically include less than 1% of alerted images, which typically occur less than 1% of the time, resulting in PixMin alert compression greater than 10,000:1.
- Little or no required training data. For this case study, the imagery provided by Workswell was more than ample to produce the results shown below.
- Substantial training analysis reduction. For this case study, we configured PixMin to obtain the results shown in less than a day.

PixMin processed the 77 pairs of images sequentially to reflect operational reality, as if they were fed in real-time from an Ethernet cable connected to an elevated camera. PixMin detected human signatures perfectly, producing no false alerts and detecting every person within each frame. PixMin produced the alert map shown in the left frame below automatically during thermal image processing. PixMin then produced the alert map shown in the right frame below by using the output coordinates from thermal detection on mark visual alert map as shown.



PixMin produced these perfect event detection results using event detection features that have taken years to develop. Among them, precise pixel alignment was especially necessary in this case. Without precise pixel alignment, the pipeline hot spots shown in the thermal images would have swamped precise person detection. With pixel alignment, PixMin not only detected persons near hot piping; PixMin could have also picked up subtle piping heat changes as well.

The figure below shows chips that PixMin produced. PixMin produced thermal detection chips in the top row during automatic thermal detection. PixMin then produced the corresponding chips in the bottom row quickly, using event location coordinates produced during thermal event detection. As shown, the chips look a bit blurry. The chips will look sharper operationally, when we use full resolution input imagery instead of highly compressed imagery to produce them.

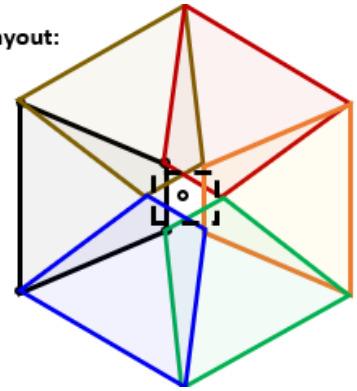


Broad Coverage Potential

Camera tilting can increase ground coverage. The Wiris Pro camera may be mounted on a gimbal, capable of tilting and panning the camera on demand as well as repositioning the camera several times per second. The figures on the left show how the thermal camera can be tilted upward, repositioned, and triggered to produce extended coverage from an altitude of 100 m. The smaller figure shows a coverage region from five snapshots taken 72 degrees apart, with the camera tilted upward 25 degrees for each snapshot. The figure shows each outward looking camera position's coverage with a different color. Overall coverage diameter is 248 m. The figure on the right shows a coverage region from six snapshots taken 60 degrees apart. Coverage diameter is 640 degrees. If, in that case, an additional image facing downward is captured, its coverage as shown by the dashed rectangle will include an area inside the rectangle that the tilted camera images will not cover. Gimbal repositioning speed, and PixMin detection speed will enable both regions to be covered and processed once every two seconds or faster.

five shots/cycle layout:
Coverage diameter
= 248 m

Seven shots/cycle layout:
Coverage diameter
= 640 m.



Summary

In this report, we have introduced a system for automatically detecting warm bodies and nonbiological thermal events from elevated imagery. By delivering an automatic alert when and only when an event occurs, PixMin frees operators from continuous manual monitoring. PixMin produces full resolution alert sub-images that reduce massive streams of imagery to useful information. When combined with commercially available components, PixMin can be delivered quickly and affordably. Wiris Pro cameras and PixMin automatic event detections stand out when compared to available alternatives. We have provided results from a case study showing that PixMin can quickly, continuously, and precisely detect people within a thermally rich environment. We, the Brainlike Team, stand ready to deliver powerful related solutions for a broad variety of event detection applications. For more information, feel free to contact us.